Reports From Party to the Investigation

1. Honeywell
2. Woodward Fuel Controls: (See Attachment 2 of Honeywell's Report)

TEARDOWN REPORT OF TWO MODEL TPE331-5-252M TURBOPROP ENGINES SERIAL NUMBERS P-30003C AND P-30012C

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Approved By: [redacted]

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TEARDOWN REPORT OF TWO MODEL TPE331-5-252M TURBOPROP ENGINES SERIAL NUMBERS P-30003C AND P-30012C

1.0 INTRODUCTION AND SUMMARY

1.1 PURPOSE

This report presents the findings of the teardown inspection conducted on two Honeywell (Garrett) Model TPE331-5-252M Turboprop Engines, Serial Numbers P-30003C and P-30012C, at the Product Safety & Integrity Investigation Laboratory in Phoenix, AZ on February 8 and 9, 2000.

The inspection was conducted at the request of, and under the cognizance of, the National Transportation Safety Board (NTSB).

1.2 BACKGROUND

The engines, Serial Numbers P-30003C and P-30012C, were installed in the left and right nacelles respectively, of a Mitsubishi MU-2B-26A aircraft, Registration Number N386TM. The aircraft crashed shortly after takeoff from San Antonio, Texas on January 22, 2000. Witness reports indicated that the right propeller was not rotating just after lift-off.

The engines were delivered to the Product Safety and Integrity Investigation Laboratory where they were secured in a locked storage area until the teardown inspection commenced.

1.3 SUMMARY

The teardown and examination of the left engine (S/N P-30003C) disclosed that the type and degree of damage was indicative of engine rotation and operation at the time of impact with the ground.

No pre-existing conditions were found on the left engine (S/N P-30003C) that would have interfered with normal operation.

The teardown and examination of the right engine (S/N P-30012C) disclosed that the type and degree of damage was indicative of an engine that was not operating at the time of impact.

The right engine (S/N P-30012C) fuel bypass valve was found to be inoperative. Excluding this condition, no pre-existing conditions were found on the right engine that would have interfered with normal operation.

2.0 FINDINGS OF TPE331-5-252M, TURBOPROP ENGINE, SERIAL NUMBER P-30003C, LEFT ENGINE

NOTES

All references to position are aft looking forward, unless otherwise noted.

All observations reported herein are based on visual examinations with the unaided eye, unless otherwise noted.

2.1 GENERAL

(a) General:

- The engine was received in a Honeywell engine-shipping container (Figure 1).
- There was evidence of fire damage (Figures 2, 3, and 4).
- There was soot covering the combustor plenum area and the fuel control area.
- The engine propeller shaft was not free to rotate upon initial inspection.
- The engine power section was not free to rotate upon initial inspection.
- There was soot in the air inlet (Figure 5).

(b) Oil flow metal (beta) tube:

- Bent in multiple locations.

(c) Mounts (Figure 6):

Right aircraft/engine mount:

- One bolt was loose.
- Intact

Top aircraft/engine mount:

- Fractured.

Left aircraft/engine mount:

- Intact

2.2 OUTPUT GEARBOX (NOSE CONE) ASSEMBLY

(a) Nose-cone housing (Figures 7 and 8):

- Fractured at five mounted holes.
- There was dirt adhering to the external surfaces.
- Rotational scoring adjacent to the propeller seal.

(b) Propeller mount flange:

- Fractured and torn with approximately 60 degrees missing (Figure 5).

Propeller shaft mount flange alignment dowels:

- One was undamaged and the other was not returned (Figure 5).

Forward propeller shaft ball bearing mount bolts:

- Fractured.

(c) Propeller shaft:

- Rotational scoring through approximately 270 degrees on the aft taper (Figure 10).
- Rotational scoring through 360 degrees in the area adjacent to the propeller shaft nut (Figure 9) with corresponding rotational scoring on the sun gear (Figure 15).

Propeller shaft nut:

- Appeared to be undamaged.

Forward propeller shaft seal:

- Appeared to be undamaged.

Propeller shaft coupling:

- Appeared to be undamaged.

(d) Propeller Bearings:

Propeller shaft forward ball bearing:

- Appeared to be undamaged.

Propeller shaft aft ball bearing:

- Appeared to be undamaged.

Propeller shaft roller bearing:

- Appeared to be undamaged.

(e) Propeller Shaft Air/Oil Seals:

Propeller shaft air/oil carbon seal:

- Carbon element was fractured.

Propeller shaft air/rotor seal:

- Fractured.

(f) Ring gear:

- Appeared to be undamaged.

Ring gear support:

- Gouged by the planetary gears in eight locations (Figure 13) with corresponding damage to the planetary gears (Figure 12).

Ring gear retainers:

- Appeared to be undamaged.

(g) Air / Oil Vent Valve (Figure 14):

- Appeared to be undamaged.
- Exterior covered with dirt.

2.3 INTERMEDIATE GEARBOX (DIAPHRAGM) ASSEMBLY

(a) Diaphragm Housing:

Forward diaphragm housing:

- Fractured at three mounting holes.

Aft diaphragm housing (Figure 16):

- Cracked in multiple locations.

(b) Bull gear:

- Appeared to be undamaged.
- Not disassembled, rotated with some resistance.

Forward bull-gear bearing:

- Displaced aft but otherwise appeared undamaged.

Aft bull-gear bearing:

- The outer race was damaged.
- Displaced aft.

(c) Sun gear:

- Rotational scoring on the forward face and inner bore through 360 degrees (Figure 15) with corresponding rotational scoring on the propeller shaft (Figure 9).
- Shavings were found on the forward face, inner-bore.

(d) High speed pinion (HSP):

- Rotated freely.
- Gouged on three teeth.

Forward high speed pinion bearing:

- Appeared to be undamaged.

Aft high speed pinion bearing:

- Appeared to be undamaged.

(e) HSP-to-power section coupling shaft:

- The unit was not disassembled for a detailed inspection yet appeared to be undamaged.

Shouldered ball-lock shaft:
- Not accessed during the examination.

Negative torque sensor (NTS) quill shaft:
- Not accessed during the examination.

(f) Hydraulic pump drive gearshaft:
- Rotated freely.
- Appeared to be undamaged.

(g) Propeller governor drive:
- Appeared to be undamaged.

(h) Starter/generator drive gearshaft:
- Damaged on the spline interface lip.

(i) Gearbox oil-scavenge pump drive shaft:
- Displayed greese on the splines.
- Bent on the flange near the oil scavenge pump.

(j) Idler spur gearshaft:
- Fractured on the bearing race in the diaphragm (Figure 17).

(k) Planet gear assembly:
Planet gear carrier (Figure 11):
- Appeared to be undamaged.

All four planet gears:
- Scoring on the aft face (Figure 12) with corresponding damage on the ring gear support (Figure 13).
- Not disassembled, rotated with some resistance.

2.4 ACCESSORY DRIVE HOUSING (GEARCASE) ASSEMBLY

(a) Exterior (non oil-wetted) of the gearcase housing:
- Intact.

(b) Anti-ice shield:
- Intact.

(c) Air inlet portion of the gearcase assembly:
- Intact.

(d) Forward (compressor) main-shaft nut:
- Appeared to be undamaged.

(e) Main shaft gear:
- Appeared to be undamaged.

(f) Compressor bearing:
- Appeared to be undamaged.
- Contained residual oil.

(g) Compressor air/oil carbon seal:
- Appeared to be undamaged.

(h) Fuel-pump drive shaft (Figure 56):
- Appeared to be undamaged.
- Displayed grease on the splines.

(i) Gearbox oil-scavenge pump drive gearshaft:
- Appeared to be undamaged.
- Rotated freely.

(j) Tach/generator drive gearshaft:
- Appeared to be undamaged.
- Rotated freely.

(k) Engine Mounting Pads:

Left aircraft/engine mount pad:
- Intact.

Right aircraft/engine mount pad:
- Intact.

Top aircraft/engine mount pad:
- Intact.

2.5 TORQUE SENSOR SYSTEM AND DDFC GEAR SYSTEM

(a) Torque sensor housing (Figures 18 and 20):
- Part Number: 896826-8.
- Cracked adjacent to the helical cam gear.

(b) First direct drive fuel-control (DDFC) gear (through the torque sensor housing):
- Appeared to be undamaged.

(c) Second DDFC gear (through the torque sensor housing):

- Gearshaft fractured (Figures 18, 20, and 21).

(d) Third DDFC gear (double gear):

- Appeared to be undamaged (Figures 19 and 21).

(e) Fourth DDFC gear (attached to the tach/generator drive gear):

- Web was bent (Figure 22).

(f) Helical / cam gear (Figure 21):

- Appeared to be undamaged.

2.6 COMPRESSOR SECTION

(a) Shouldered (main) shaft (Figure 23):

- Appeared to be undamaged.

(b) Torsion shaft (Figure 23):

- Fractured.

(c) First-stage compressor impeller shroud:

- Covered with soot.
- Contour rub through approximately 90 degrees at the exit with corresponding rotational scoring on the shroud line edge.

(d) First-stage compressor impeller (Figures 24 and 25):

- Rotational scoring on the shroud line edge with corresponding rotational scoring on the first-stage compressor impeller shroud.
- Serial Number: 4-03501-5014.
- Part Number: 896223-3.
- Rotational scoring on the aft hub through 360 degrees with a corresponding rub on the crossover duct seals (Figure 26).
- Leading-edges bent opposite to the direction of rotation on three blades.
- All of the blades were covered with soot.
- Metallic particles adhering to impeller exit flowpath channel.

First-stage compressor impeller aft curvic coupling:

- Appeared to be undamaged.

(e) First-stage compressor diffuser (crossover duct):

- Appeared to be undamaged.
- There was dirt adhering to the vane surfaces (Figure 26).

First-stage compressor diffuser labyrinth seal support:

- Intact.

Phenolic seal on the ID of the crossover duct:

- Seal was chipped in one location.
- Rubbed on seals (Figure 26) with corresponding rotational scoring on the aft hub of the first-stage compressor impeller.

(f) Housing for second-stage compressor shroud:

- Compression wrinkles (axially crushed).

(g) Second-stage impeller shroud:

- Contour rub through approximately 180 degrees at the inlet and 360 degrees at the exit (Figures 27 and 28) with corresponding rotational scoring on the second-stage compressor impeller blades (Figure 29).

(h) Second-stage compressor impeller:

- Rotational scoring at the inlet and exit on the shroud line edge of all the blades (Figure 29) with corresponding rotational scoring on the second-stage impeller shroud.
- Serial Number: 1-03501-4267.
- Part Number: 893???-?.
- All of the blades were covered with soot.

Second-stage compressor impeller forward curvic coupling:

- Appeared to be undamaged.

Second-stage compressor impeller aft curvic coupling:

- Appeared to be undamaged.

(i) Second-stage compressor diffuser vane assembly:

- Was crushed in one location (Figure 30).

2.7 COMBUSTOR SECTION

(a) Combustor plenum case (Figure 31):

- Intact.
- Soot on external surface.

(b) Combustion chamber (Figure 32):

- Appeared to be undamaged.

(c) Inner transition liner (Figure 33):

- Appeared to be undamaged.

(d) Outer transition liner (Figure 34):

- Appeared to be undamaged.
- There was dirt adhering to the inner surfaces.

Outer transition liner labyrinth seal:

- Some wear but otherwise appeared to be undamaged.

2.8 TURBINE SECTION

(a) Center curvic (Figure 35):

- Appeared to be undamaged.

Center curvic forward curvic coupling:

- Appeared to be undamaged.

Center curvic aft curvic coupling:

- Appeared to be undamaged.

Center curvic knife-edge seal:

- Some wear but otherwise appeared to be undamaged.

(b) First-stage turbine stator (Figure 36):

- Intact.

(c) First-stage turbine blade tip shroud (Figure 40):

- Rotational scoring through approximately 90 degrees with corresponding rotational scoring to the first-stage turbine rotor blade tips (Figure 39).

(d) First-stage turbine rotor (Figures 37 and 38):

- Part Number: 867569-7.
- Serial Number: ?45-5916?.
- Rotational scoring on all of the blade tips (Figure 39) with corresponding rotational scoring on the first-stage turbine blade tip shroud.
- Nine blades with corner separations on the blade-tip trailing edges (Figure 39).
- Rotational scoring on the aft blade platforms.
- Metal spray deposits on the suction side of the blades.
- Lot Number: 4667.

First-stage turbine forward curvic (Figure 37):

- Appeared to be undamaged.

First-stage turbine aft curvic (Figure 38):

- Appeared to be undamaged.

(e) Second-stage turbine stator:

- Intact.
- Metal spray deposits on the suction side of the vanes (Figure 41).
- There was dirt adhering to the suction surfaces of the vanes.

Second-stage turbine stator abradable seal:

- Some wear but otherwise appeared to be undamaged.

(f) Second-stage turbine blade tip shroud:

- Appeared to be undamaged.

(g) Second-stage turbine rotor (Figures 42 and 43):

- Part Number: 868272-1.
- Serial Number: 3-01345-3503.
- Rotational scoring on the aft edge of the blade tips (Figure 44).
- Rotational scoring on the aft blade platforms.
- Metal spray deposits on the suction side of the blades.
- Lot Number: 4590.

Second-stage turbine rotor knife-edge labyrinth seal:

- Some wear but otherwise appeared to be undamaged.

Second-stage turbine forward curvic (Figure 42):

- Appeared to be undamaged.

Second-stage turbine aft curvic (Figure 43):

- Appeared to be undamaged.

(h) Third-stage turbine stator (Figures 45 and 46):

- Serial Number: 6-01345-0198.
- Part Number: 868379-3.
- Intact.
- Metal spray deposits on the suction side of the vanes (Figure 47).

Third-stage turbine stator abradable seal:

- Rotational scoring through approximately 75 degrees.

(i) Third-stage turbine blade tip shroud:

- Appeared to be undamaged.

(j) Third-stage turbine rotor (Figures 48 and 49):

- Part Number: 868630-9.
- Serial Number: 8-01345-6175.
- Rotational scoring on the aft blade platforms.

- Metal spray deposits on the suction side of the blades (Figure 50).
- Lot Number: 9293.

Third-stage turbine rotor knife-edge labyrinth seal:
- Some wear but otherwise appeared to be undamaged.

Third-stage turbine forward curvic (Figure 48):
- Appeared to be undamaged.

Third-stage turbine aft curvic (Figure 49):
- Appeared to be undamaged.

(k) Rear curvic coupling (Figure 51):
- Appeared to be undamaged.

(l) Engine exhaust duct:
- Intact.
- Soot on the external surfaces.

(m) Thermocouple harness assembly (Figure 53):
- Appeared to be undamaged.

Interstage turbine temperature (ITT) thermocouple probes:
- Appeared to be undamaged.

(n) Turbine bearing support housing (Figure 52):
- Intact.

(o) Turbine oil-scavenge pump drive shaft:
- Appeared to be undamaged.
- Rotated freely.

(p) Turbine air/oil carbon seal:
- Appeared to be undamaged.

(q) Turbine roller bearing:
- Appeared to be undamaged.

(r) Aft (turbine) main-shaft nut:
- Appeared to be undamaged.

2.9 FUEL

(a) Fuel shutoff solenoid valve (Figure 55):

- Part Number: 394230-4-1.
- Serial Number: P-3757.
- Contained residual fuel.
- The solenoid was partially separated from valve body.
- Dented on the solenoid cover.

(b) Fuel pump (Figures 57 and 58):

- Serial Number: P-143187.
- Part Number: 869151-5.
- Appeared to be undamaged.
- The fuel pump was functionally tested, and found to be operable (see Appendix I). The following conditions were observed:
  1. The discharge fuel flow recorded at an input shaft speed of 545 +/- 10 rpm was 36 pph, 104 pph below the minimum limit of 140 pph. This condition would have resulted in lower than specification fuel flow during the initial engine start sequence and would not have affected satisfactory engine operation.
  2. The discharge fuel flow recorded at an input shaft speed of 4536 +/- 10 rpm was 1700 pph, 350 over the minimum limit of 1350 pph. This condition would not have affected satisfactory engine operation.
  3. The discharge pressure recorded at an input shaft speed of 4536 +/- 10 rpm was 820 psig, 505 psig below the minimum limit of 1325 psig. Fuel control discharge pressure at maximum fuel flow is 575 psig, 245 psig below the recorded pump discharge pressure. Typical pressure losses through the fuel control are less than 100 psig. Sufficient margin remains to conclude that this condition would not have affected satisfactory engine operation.

(c) Fuel control (Figures 57 and 58):

- Dataplate and flight idle adjustment plate were missing.
- Covered in soot.
- The power lever was sheared off.
- The speed lever was bent.
- Not functionally tested in Phoenix due to damage. The unit was sent to Woodward Governor Company for testing and evaluation (see Attachment I).

(d) Fuel flow divider valve (Figure 61):

- Part Number: 867465-1.
- Appeared to be undamaged.
- Covered in soot.
- Not functionally tested.

(e) Secondary (run) fuel manifold hose assembly (Figure 59):

- Fractured in one location.

- External surfaces discolored and burned.

Run fuel nozzles:
- Carbon deposits on all of the nozzles.
- Appeared to be undamaged.

(f) Primary (start) fuel manifold hose assembly (Figure 60):
- External surfaces discolored and burned.

Start fuel nozzles:
- Carbon deposits on two nozzles.

2.10 OIL

(a) Magnetic drain plug (chip detector):
- A single chip was found on the tip (Figure 65).

(b) Oil pressure pump:
- Rotated freely.
- Appeared to be undamaged.

(c) Gearbox oil-scavenge pump:
- Drive was not free to rotate.
- Appeared to be undamaged.

(d) Turbine oil-scavenge pump (Figure 63):
- Rotated freely.
- Appeared to be undamaged.

(e) Oil Tank (Figure 62):
- Crushed.

(f) Oil Temperature Sensor (Figure 66):
- Appeared to be undamaged.

(g) NTS Oil Regulator (Figure 67):
- O-rings intact.
- Appeared to be undamaged.

2.11 ELECTRICAL

(a) Ignition exciter:
- Serial Number: 391725.
- Part Number: 868962-2.
- Model Number: TCN-2120.

- Appeared to be undamaged.

(b) Excitor to ignitor lead assembly:
- Wiring was burned.

(c) Ignitors (Figure 54):
Dummy ignitor plug:
- Appeared to be undamaged.

Ignitor (1):
- Appeared to be undamaged.

Ignitor (2):
- Appeared to be undamaged.

2.12 MISCELLANEOUS

(a) Propeller governor (Figure 68):
- Serial Number: P-120.
- Part Number: 895490-5.
- Drive spline was not free to rotate.
- Not functionally tested.

(b) Propeller pitch control (Figure 69):
- Serial Number: P-1560.
- Part Number: 895481-2 Series 3.
- Covered in soot.
- Mount flange was fractured.

(c) Starter/generator (aircraft component):
- Not returned.

(d) Tach generator:
- Serial Number: 8914.
- Part Number: AG34.
- Appeared to be undamaged.

(e) Anti-ice valve (Figure 70):
- Not functionally tested.
- Part Number: 319980-6-1.
- Serial Number: P-6402.
- The solenoid was partially separated from valve body, which is attributed to impact damage.

- Closed. The valve was x-rayed and the internal springs were found to be intact. The valve seats were still engaged despite the partial separation of the solenoid from the actuator housing.

(f) Feather valve:

- Not functionally tested.
- Actuator arm connector was separated such that the internal spring was visible.
- Oil transfer tube intact (Figure 64).

(g) Fuel Bypass Valve:

- Serial Number: 4-08044-291.
- Part Number: 895380-4.
- Appeared to be undamaged (Figure 72).
- Functionally tested (See Appendix I). No discrepancies were found that would have affected satisfactory engine operation.

(h) TT2 Temperature Sensor (Figure 71):

- Appeared to be undamaged.
- Not functionally tested.

3.0 FINDINGS OF TPE331-5-252M, TURBOPROP ENGINE, SERIAL NUMBER P-30012C, RIGHT ENGINE

3.1 GENERAL

(a) General:

- The engine was received in a Honeywell engine-shipping container (Figure 73).
- There was evidence of fire damage (Figures 74, 75, and 76).
- There was evidence of impact damage (Figures 75 and 76).
- The engine propeller shaft was not free to rotate upon initial inspection.
- The engine power section was not free to rotate upon initial inspection.

(b) Mounts (Figure 77):

Right aircraft/engine mount:

- Intact.

Left aircraft/engine mount:

- Intact.

Top aircraft/engine mount:

- Fractured.

3.2 OUTPUT GEARBOX (NOSE CONE) ASSEMBLY

(a) Nose-cone housing (Figures 78 and 79):

- Fractured.
- Punctured on the lower left side.
- There was soot adhering to the external surface.

(b) Propeller mount flange (Figure 79):

- Appeared to be undamaged.

Propeller shaft mount flange alignment dowels (Figure 79):

- Appeared to be undamaged.

Forward propeller shaft ball bearing mount bolts (Figure 81):

- Fractured, bolts removed by hand.

(c) Propeller shaft:

- Rotational scoring through approximately 180 degrees near the aft taper (Figure 83).
- Witness mark through 360 degrees near the propeller shaft nut (Figure 82).

Propeller shaft nut:

- Appeared to be undamaged.

Forward propeller shaft seal:

- Appeared to be undamaged.

Propeller shaft coupling:

- Appeared to be undamaged.

(d) Propeller Bearings:

Propeller shaft forward ball bearing:

- Appeared to be undamaged.

Propeller shaft aft ball bearing (Figure 84):

- Appeared to be undamaged.

Propeller shaft roller bearing:

- Appeared to be undamaged.

(e) Propeller Shaft Air/Oil Seals:

Propeller shaft air/oil carbon seal:

- Appeared to be undamaged.

Propeller shaft air/rotor seal:

- Appeared to be undamaged.

(f) Ring gear:

- Appeared to be undamaged.

Ring gear support:

- Gouged by the planetary gears on the forward face (Figure 87) with corresponding damage to the planetary gears (Figure 86).
- Displayed two elongated mounting holes.

Ring gear retainers:

- Appeared to be undamaged (Figure 88).

(g) Air / Oil Vent Valve (Figure 80):

- Appeared to be undamaged.

3.3 INTERMEDIATE GEARBOX (DIAPHRAGM) ASSEMBLY

(a) Diaphragm Housing:

Forward diaphragm housing (Figure 91):

- Intact.

Aft diaphragm housing (Figure 90):

- Intact.

(b) Bull gear:

- Rotated freely.
- Not disassembled, appeared to be undamaged.

Forward bull-gear bearing:

- Not disassembled, appeared to be undamaged.

Aft bull-gear bearing:

- Not disassembled, appeared to be undamaged.

(c) Sun gear:

- Rotational scoring on the aft face of the sun gear nut with corresponding damage to the torque sensor housing (Figure 94).

(d) High speed pinion (HSP):

- Rotated freely.
- Appeared to be undamaged.

Forward high-speed pinion bearing:

- Not disassembled but rotated freely.

Aft high-speed pinion bearing:

- Not disassembled but rotated freely.

(e) HSP-to-power section coupling shaft (Figure 89):

- Appeared to be undamaged.

Shouldered ball-lock shaft (Figure 89):

- Appeared to be undamaged.

Negative torque sensor (NTS) quill shaft (Figure 89):

- Appeared to be undamaged.

(f) Hydraulic pump drive gearshaft:

- Appeared to be undamaged.
- Rotated freely.

(g) Propeller governor drive:

- Appeared to be undamaged.
- Rotated freely.

(h) Starter/generator drive gearshaft:
- Appeared to be undamaged.
- Rotated freely.

(i) Gearbox oil-scavenge pump drive shaft:
- Bent flange.

(j) Idler spur gearshaft:
- Appeared to be undamaged.
- Rotated freely.

(k) Planet gear assembly (Figure 85):
Planet gear carrier:
- Intact.

All four planet gears:
- Rotated freely.
- Displayed line pattern across aft gear face and teeth (Figure 86) with corresponding damage to the ring gear support (Figure 87).

All four planet gear bearings:
- Not accessed but appeared to be undamaged.

3.4 ACCESSORY DRIVE HOUSING (GEARCASE) ASSEMBLY

(a) Gearcase housing (Figures 92 and 93):
- Impact damage on the lower right side in the air inlet and bell area.
- Witness mark on feather valve transfer tube boss (Figure 94).

(b) Anti-ice shield (Figure 92):
- Torn and crushed.

(c) Air inlet portion of the gearcase assembly (Figure 92):
- Cracked in two locations.

(d) Forward (compressor) main-shaft nut (Figure 101):
- Appeared to be undamaged.
- Handtight.

(e) Main shaft gear (Figure 101):
- Appeared to be undamaged.

(f) Compressor bearing (Figure 100):
- Appeared to be undamaged.

(g) Compressor air/oil carbon seal:

- Appeared to be undamaged.

(h) Fuel-pump drive shaft (Figure 141):

- Appeared to be undamaged.

(i) Gearbox oil-scavenge pump drive gearshaft:

- Appeared to be undamaged.
- Rotated freely.

(j) Tach/generator drive gearshaft:

- Appeared to be undamaged.
- Rotated freely.

(k) Engine Mounting Pads:

Left aircraft/engine mount pad:

- Intact.

Right aircraft/engine mount pad:

- Intact.

Top aircraft/engine mount pad:

- Intact.

(l) NTS Check Valve and Orifice (Figure 95):

- Intact.
- No blockage observed.

3.5 TORQUE SENSOR SYSTEM AND DDFC GEAR SYSTEM

(a) Torque sensor housing (Figures 93, 96, and 97):

- Serial Number: P-7767.
- Part Number: 3101726-2 Series 9.
- Gouged on the upper, forward face with corresponding damage to the sun gear nut.

(b) First direct drive fuel-control (DDFC) gear (through the torque sensor housing):

- Appeared to be undamaged.
- Rotated freely.
-

(c) Second DDFC gear (through the torque sensor housing):

- Appeared to be undamaged.
- Rotated freely.

(d) Third DDFC gear (double gear):

- Appeared to be undamaged (Figure 98).
- Rotated freely.

(e) Fourth DDFC gear (attached to the tach/generator drive gear):

- Rotated freely.
- Web was bent (Figure 99).

(f) Helical / cam gear (Figure 98):

- Appeared to be undamaged.

3.6 COMPRESSOR SECTION

(a) Shouldered (main) shaft (Figure 102):

- Appeared to be undamaged.

(b) Torsion shaft (Figure 103):

- Appeared to be undamaged.

(c) First-stage compressor impeller shroud (Figure 104):

- Contour rub through approximately 10 degrees at the exit (Figure 105).
- Displayed witness marks corresponding to the impeller blades (Figure 106).

(d) First-stage compressor impeller (Figures 107 and 108):

- Intact.
- Serial Number: 4-03501-5016.
- Part Number: Unreadable.
- There was dirt adhering to the blades and flowpath surfaces.

First-stage compressor impeller aft curvic coupling (Figure 108):

- Appeared to be undamaged.

(e) First-stage compressor diffuser (crossover duct) (Figure 109):

- Dented in the 6 o'clock position.
- Heavy soot on exit vanes (inlet to the second stage).

First-stage compressor diffuser labyrinth seal support:

- Intact.

Phenolic seal on the ID of the crossover duct:

- Appeared to be undamaged.

(f) Housing for second-stage compressor shroud (Figure 110):

- Compression wrinkles (axial damage).

- Covered with soot on external surfaces.

(g) Second-stage impeller shroud:

- Contour rub through 360 degrees (Figure 112) with corresponding rotational scoring on the second-stage compressor impeller blades (Figures 113, 114, 115, and 116).
- Displayed witness marks corresponding to the second stage impeller blades (Figures 111 and 112).

(h) Second-stage compressor impeller (Figure 113):

- Rotational scoring on the shroud line edge of all the blades (Figures 113, 114, 115, and 116) with corresponding rotational scoring on the second-stage impeller shroud (Figure 112).
- Serial Number: 7-03501-6500.
- Part Number: 893482-1.
- Lot Number: 0144.
- Covered with soot on the blades and flowpath (Figure 116).

Second-stage compressor impeller forward curvic coupling:

- Appeared to be undamaged (Figure 113).

Second-stage compressor impeller aft curvic coupling:

- Appeared to be undamaged (Figure 114).

(i) Second-stage compressor diffuser vane assembly:

- Intact.
- Displayed metallic particles at the exit of the vanes and along the flowpath (Figure 116).

3.7 COMBUSTOR SECTION

(a) Combustor plenum case (Figures 117 and 118):

- Compression wrinkles (axial damage).
- Rear mount separated and the boss at 6 o'clock pulled out (Figure 117).

(b) Combustion chamber (Figure 119):

- Dented at 6 o'clock.

(c) Inner transition liner:

- Appeared to be undamaged.

(d) Outer transition liner:

- Appeared to be undamaged.
- Light debris in the dished area.

Outer transition liner honeycomb seal:

- Some wear but otherwise appeared to be undamaged.

3.8 TURBINE SECTION

(a) Center curvic (Figure 120):

- Appeared to be undamaged.

Center curvic forward curvic coupling:

- Appeared to be undamaged.

Center curvic aft curvic coupling:

- Appeared to be undamaged.

Center curvic knife-edge seal:

- Some wear but otherwise appeared to be undamaged.

(b) First-stage turbine stator (Figures 121 and 122):

- Metal spray deposits on the leading edge of the vanes.
- Displayed surface wrinkles on five vanes.
- Metal spray deposits on the pressure side of the vanes.
- Mid-span on one vane was cracked.

(c) First-stage turbine blade tip shroud (Figure 126):

- Rotational scoring through approximately 60 degrees with corresponding rotational scoring to the first-stage turbine blade tips (Figure 125).

(d) First-stage turbine rotor:

- Part Number: 867569-7.
- Serial Number: 3-01345-5922.
- Rotational scoring on half of the blade tips (Figure 125) with corresponding rotational scoring on the first-stage turbine blade tip shroud (Figure 125).
- Metal spray deposits on the suction side of the blades (Figure 124).
- Lot Number: 4667.
- Metal spray deposits on the leading edge of the blades (Figure 123).

First-stage turbine forward curvic:

- Appeared to be undamaged.

First-stage turbine aft curvic:

- Appeared to be undamaged.

(e) Second-stage turbine stator (Figures 127 and 128):

- Intact.

Second-stage turbine stator abradable seal:

- Some wear but otherwise appeared to be undamaged.

(f) Second-stage turbine blade tip shroud:

- Appeared to be undamaged.

(g) Second-stage turbine rotor (Figures 129 and 130):

- Intact.
- Part Number: 868272-1.
- Serial Number: 3-01345-3585.
- Lot Number: 4590.

Second-stage turbine rotor knife-edge labyrinth seal:

- Some wear but otherwise appeared to be undamaged.

Second-stage turbine forward curvic (Figure 129):

- Appeared to be undamaged.

Second-stage turbine aft curvic (Figure 130):

- Appeared to be undamaged.

(h) Third-stage turbine stator (Figures 131 and 132):

- Serial Number: 5-01345-3126.
- Part Number: 868379-3.
- Intact.

Third-stage turbine stator abradable seal:

- Some wear but otherwise appeared to be undamaged.

(i) Third-stage turbine blade tip shroud:

- Appeared to be undamaged.

(j) Third-stage turbine rotor (Figures 133 and 134):

- Intact.
- Part Number: 868630-9.
- Serial Number: ?-01345-270.
- Lot Number: 0766.

Third-stage turbine rotor knife-edge labyrinth seal:

- Some wear but otherwise appeared to be undamaged.

Third-stage turbine forward curvic (Figure 133):

- Appeared to be undamaged.

Third-stage turbine aft curvic (Figure 134):

- Appeared to be undamaged.

(k) Rear curvic coupling (Figure 135):

- Appeared to be undamaged.

(l) Engine exhaust duct (Figure 138):

- Intact.

(m) Thermocouple harness assembly (Figure 139):

- Intact.

Interstage turbine temperature (ITT) thermocouple probes:

- Appeared to be undamaged.

(n) Turbine bearing support housing (Figure 137):

- Intact.

(o) Turbine oil-scavenge pump drive shaft (Figure 148):

- Appeared to be undamaged.
- Rotated freely.

(p) Turbine air/oil carbon seal (Figure 136):

- Appeared to be undamaged.

(q) Turbine roller bearing (Figure 136):

- Appeared to be undamaged.

(r) Aft (turbine) main-shaft nut (Figure 136):

- Appeared to be undamaged.

3.9 FUEL

(a) Fuel shutoff solonoid valve (Figure 140):

- Part Number: 394230-4-1 Series 4.
- Serial Number: P-3476.
- The solenoid was partially separated from valve body.
- Covered with soot.

(b) Fuel pump (Figures 142 and 143):

- Serial Number: P-1138420.
- Part Number: 869151-5.
- The mount flange was bent.
- Covered with soot.

- The fuel pump was functionally tested, and found to be operable (see Appendix I). The following conditions were observed:
  1. The discharge fuel flow recorded at an input shaft speed of 545 +/- 10 rpm was 0 pph, 140 pph below the minimum limit of 140 pph. This condition would have resulted in lower than specification fuel flow during the initial engine start sequence and would not have affected satisfactory engine operation.
  2. The discharge fuel flow recorded at an input shaft speed of 4536 +/- 10 rpm was 1060 pph, 290 pph below the minimum specification limit of 1350 pph. At 1060 pph, the pump is still providing almost twice as much fuel flow as required by the fuel control at its maximum fuel flow condition of 555 pph. This condition would not have affected satisfactory engine operation.
  3. The discharge pressure recorded at an input shaft speed of 4536 +/- 10 rpm was 860 psig, 465 psig below the minimum limit of 1325 psig. Fuel control discharge pressure at maximum fuel flow is 575 psig, 285 psig below the recorded pump discharge pressure. Typical pressure losses through the fuel control are less than 100 psig. Sufficient margin remains to conclude that this condition would not have affected satisfactory engine operation.

(c) Fuel control (Figures 142 and 143):

- Serial Number: 1297874.
- Part Number: 893561-11.
- Drive was free to rotate.
- Covered in soot.
- The power lever shaft was bent and not free to rotate.
- The speed lever was free to rotate.
- Not functionally tested in Phoenix due to damage. The unit was sent to Woodward Governor Company for testing and evaluation (see Attachment II).

(d) Fuel flow divider valve (Figure 146):

- Not functionally tested.
- Part Number: 967464-1.
- Appeared to be undamaged.
- Covered in soot.

(e) Secondary (run) fuel manifold hose assembly (Figure 144):

- Displayed four segments where sheathing was burned off.

Run fuel nozzles:

- Appeared to be undamaged.

(f) Primary (start) fuel manifold hose assembly (Figure 145):

- Fractured at the main input line.
- Melted sheathing on all segments.
- Covered with soot.

Start fuel nozzles:

- Carbon deposits on two nozzles.
- Appeared to be undamaged.

3.10 OIL

(a) Magnetic drain plug (chip detector):

- Not accessed during the examination.

(b) Oil pressure pump:

- Rotated freely.
- Appeared to be undamaged.

(c) Gearbox oil-scavenge pump:

- Rotated freely.
- Appeared to be undamaged.

(d) Turbine oil-scavenge pump (Figure 148):

- Rotated freely.
- Appeared to be undamaged.

(e) Oil tank (Figure 147):

- Crushed.

3.11 ELECTRICAL

(a) Ignition exciter (Figure 149):

- Serial Number: 371965.
- Part Number: 868962-2.
- Crushed.

(b) Excitor to ignitor lead assembly (Figure 150):

- Displayed one frayed and separated jacket, however the lead was intact.
- Covered with soot.

(c) Ignitors (Figure 151):

Dummy ignitor plug:

- Appeared to be undamaged.

Ignitor (1):

- Appeared to be undamaged.

Ignitor (2):

- Appeared to be undamaged.

3.12 MISCELLANEOUS

(a) Propeller governor (Figure 152):

- Serial Number: P-220.
- Part Number: 895490-5.
- Drive spline was not free to rotate.
- Fractured housing.
- Mount flange was fractured.
- The input lever was not free to move.
- Partially disassembled, "speeder" spring was found to be intact and properly seated.

(b) Propeller pitch control (Figure 153):

- Serial Number: P-1784.
- Part Number: 895481-2 Series 3.
- There was dirt adhering to the external surfaces.
- Partially disassembled, pin and NTS lockout valve intact.
- Sleeve was free to move.

(c) Starter/generator (aircraft component) (Figure 154):

- Burnt wiring but otherwise appeared undamaged.
- Covered with soot.

(d) Tach generator (Figure 155):

- Rotated freely.
- Serial Number: 8949.
- Part Number: AG34.
- Covered on the exterior with debris and soot.
- Displayed a burned lead wire.

(e) Anti-ice valve (Figure 156):

- Part Number: 319980-6-1.
- Serial Number: P-6531.
- Fractured connector socket.
- The solenoid was partially separated from valve body, which is attributed to impact damage.
- Covered with soot.
- Found in open position. The valve was x-rayed and the internal springs were found to be intact. The valve appears to be open due to the partial separation of the solenoid from the actuator housing.

(f) Feather valve:

- Actuator arm connector cap was missing yet the valve actuated freely.

(g) Inlet air temperature sensor (Figure 157):

- Crushed and burned.

(h) Fuel Bypass Valve (Figure 158):

- Serial Number: 3-08044.
- Part Number: 895380-4.
- Appeared to be undamaged.
- Functionally tested (see Appendix I). The valve did not provide bypass fuel flow at any current delivered, this means the engine would not mechanically be limited at the specified torque or gas temperature limits.

4.0 ANALYSIS AND CONCLUSIONS

4.10 Analysis:

Rotation at the time of ground impact, for the left engine S/N P-30003C, was evidenced by the following conditions:

- Rotational scoring on the propeller shaft with corresponding rotational scoring on the inner bore of the sun gear.
- Scoring on the aft face of the all four planet gears with corresponding damage to the ring gear support.
- Contour rub on the first-stage compressor impeller shroud with corresponding rotational scoring on the shroud line edge of the first-stage compressor impeller blades.
- Rotational scoring on the aft hub of the first-stage compressor impeller.
- Three blades of the first-stage compressor impeller displayed leading-edges bent opposite to the direction of rotation.
- Contour rub of the second-stage impeller shroud with corresponding rotational scoring on the shroud line edge of the second-stage compressor impeller blades.
- Rotational scoring on the first-stage turbine blade tip shroud with corresponding rotational scoring on the blade tips of the first-stage turbine rotor.
- Rotational scoring on the aft blade platforms of the first-stage turbine rotor.
- Rotational scoring on the aft edge of the blade tips of the second-stage turbine rotor.
- Rotational scoring on the aft blade platforms of the second-stage turbine rotor.
- Rotational scoring on the third-stage turbine stator abradable seal.
- Rotational scoring on the aft blade platforms of the third-stage turbine rotor.

Operation at the time of ground impact, for the left engine S/N P-30003C, was evidenced by the following conditions:

- Metal spray deposits on the suction side of the blades in the first-stage turbine rotor.
- Metal spray deposits on the suction side of the vanes of the second-stage turbine stator.
- Metal spray deposits on the suction side of the blades in the second-stage turbine rotor.
- Metal spray deposits on the suction side of the vanes of the third-stage turbine stator.
- Metal spray deposits on the suction side of the blades in the third-stage turbine rotor.

4.11 Right Engine (S/N P-30012C) Metal Spray Deposits:

The presence of static witness marks on the compressor impeller shrouds indicates that the engine was not running at the time of impact. However, "fresh" metal spray deposits were observed on the first-stage turbine stator vanes and the first stage turbine rotor blades. Fresh "dynamic rubs" were also observed on the second stage compressor shroud leading to the conclusion that the metal spray deposits were generated from contact between the second-stage compressor impeller and its mating shroud while the engine was running. These fresh metal spray deposits are considered to be deposits that have been exposed to a turbine temperature environment for less than one hour.

In the analysis of engines that have been involved in accidents, the presence of fresh dynamic compressor rubs and metal spray deposits are normally associated with an engine that is running at the time of impact. However, in this instance, Honeywell has concluded that the fresh metal spray deposits were made prior to impact. This is based on the physical evidence that the static marks were made following the dynamic rubs.

Examination of the second-stage compressor shroud disclosed a rub that was axial in direction and very uniform in appearance. These characteristics are not typical of the type of rub experienced by an operational engine during an impact sequence. They are more typical of the type of rub experienced as a result of using engine intake anti-ice air at outside air temperatures of 4 C or above for a period of time exceeding 10 seconds.

4.2 Conclusions

The teardown and examination of the left engine (S/N P-30003C) disclosed that the type and degree of damage was indicative of engine rotation and operation at the time of impact with the ground.

No pre-existing conditions were found on the left engine (S/N P-30003C) that would have interfered with normal operation.

The teardown and examination of the right engine (S/N P-30012C) disclosed that the type and degree of damage was indicative of an engine that was not operating at the time of impact.

The right engine (S/N P-30012C) fuel bypass valve was found to be inoperative. Excluding this condition, no pre-existing conditions were found on the right engine that would have interfered with normal operation.

APPENDIX I

FUNCTIONAL TESTING DATA SHEETS

(4 pages)

left P-30003C

0122

Allied-Signal Aerospace Company
Garrett Engine Division

Allied Signal

DS-8983A
1-13-89

FUEL PUMP ACCEPTANCE TEST DATA FOR P/N 869151-1 THROUGH -7, 897400-1 THROUGH -7, 897380-1 THROUGH -10 AND 895413-1 THROUGH -12

Used With OHTI-869151 Rev_____

DATE_____ PART NO._____

LAB TEMP_____F SERIAL NO._____

FUEL TEMP_____F STATION NO._____

OHTI Paragraph No.					
3.1	Run-In Completed ☐ Leakage Check Completed ☐				
3.2	Input Shaft Speed (rpm)	Inlet Fuel Pressure (psig)	Discharge Pressure (psig)	Discharge Fuel Flow (lb/hr) Minimum	Actual
	545 ±10	10 ±1	140 ±5	140	36
	2500 ±10	10 ±1	140 ±5	*	
	2500 ±10	10 ±1	700 ±10	*	
	4000 ±10	10 ±1	700 ±10	*	
	4536 ±10	10 ±1	140 ±5	*	
	4536 ±10	10 ±1	700 ±10	1350	1700
3.3	4536 ±10	10 ±1	1375 ±50	Actual Pressure	870
3.4	Filter and Leak Check Completed ☐				
3.5	Input Shaft Torque 18 in-lb max. ☐				
4.0	Preservation - Completed ☐				

UNIT TEST: Accept _____ Reject_____ Route to QA/ENG_____

Remarks:

	Signature	Date
Technician		
Engineering		
QA		
Govt. Insp.		

* Record only upon special request from Engineering

Left P300030 Fuel Bypass Valve

DS-895380-1M
5-15-91

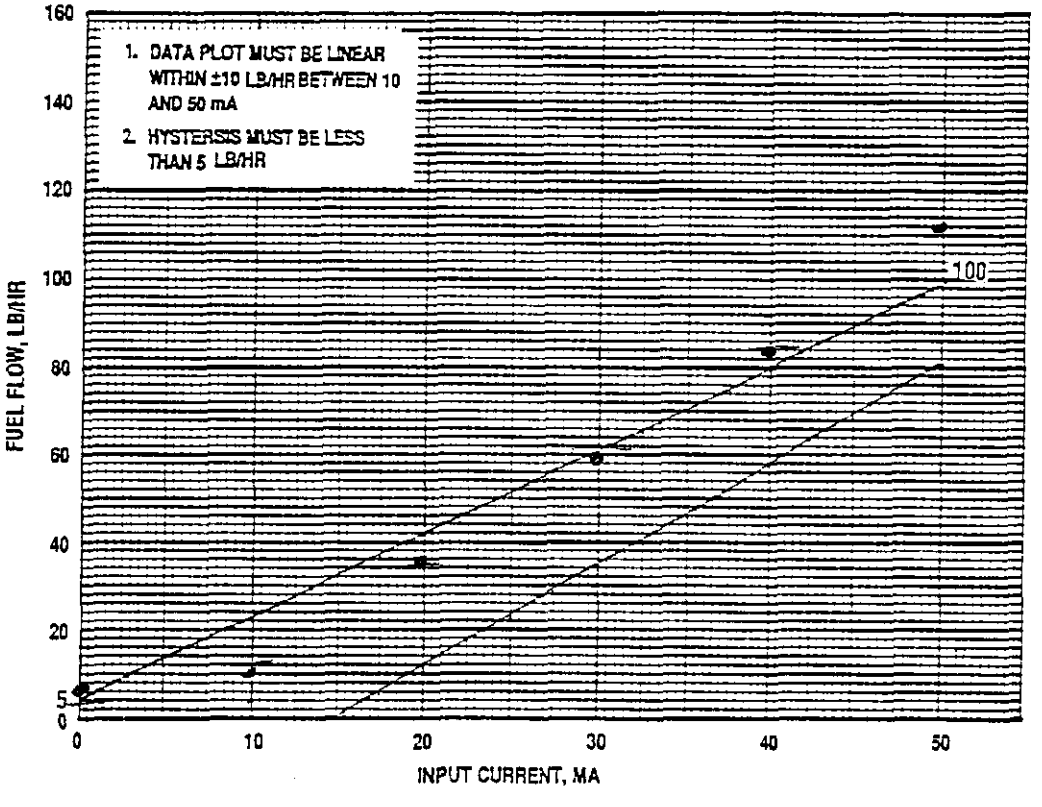
Valve Data Sheet

TI-895380 Rev: AA
Date: 2-10-2000

Valve Part Number: 895380-____ Serial Number: AA

3.1	Inspection (Check One): Accept ✓ Reject ___
3.2	Continuity Check:
(a)	Check for Short: Accept ✓ Reject ___
(b)	Resistance between pins "A" and "C" 203.1 (180 to 235 ohms required)
3.5	Torque Motor Current Cycle Check: ✓ (Check)
3.6	Internal Leakage Check: 10.8 lb/hr (5.0 lb/hr maximum allowable)
3.7	Linearity and Hysteresis Checks:

Current (±1 mA)	Actual Flow (lb/hr)
0	= 5.77
10	= 9.19
20	= 36.23
30	= 59
40	= 83
50	= 111
40	= 84
30	= 61
20	= 36
10	= 10.76
0	= 6.10



(f)	Minimum Flow = 112 (80.0 lb/hr minimum allowable) Noise (buzzing): Accept ✓ Reject ___
3.8	External Leakage Check: Accept ✓ Reject ___

Acceptance Signatures (As Required)

Test Laboratory _____

Accept ___ Reject ___

Quality Assurance _____

Remarks: _____

Right P-3001Z<

0122

Allied-Signal Aerospace Company
Garrett Engine Division

Allied Signal

DS-8983A
1-13-89

FUEL PUMP ACCEPTANCE TEST DATA
FOR P/N 869151-1 THROUGH -7,
897400-1 THROUGH -7,
897380-1 THROUGH -10
AND 895413-1 THROUGH -12

Used With
OHTI-869151
Rev _____

DATE _____ PART NO. _____

LAB TEMP _____ F SERIAL NO. _____

FUEL TEMP _____ F STATION NO. _____

OHTI Paragraph No.					
3.1	Run-In Completed ☐ Leakage Check Completed ☐				
3.2	Input Shaft Speed (rpm)	Inlet Fuel Pressure (psig)	Discharge Pressure (psig)	Discharge Fuel Flow (lb/hr) Minimum	Actual
	545 ±10	10 ±1	~~140 ±5~~ 85	140	~~0~~
	2500 ±10	10 ±1	140 ±5	*	
	2500 ±10	10 ±1	700 ±10	*	
	4000 ±10	10 ±1	700 ±10	*	
	4536 ±10	10 ±1	140 ±5	*	
	4536 ±10	10 ±1	700 ±10	1350	1060
3.3	4536 ±10	10 ±1	1375 ±50	Actual Pressure	860
3.4	Filter and Leak Check Completed ☐				
3.5	Input Shaft Torque 18 in-lb max. ☐				
4.0	Preservation - Completed ☐				

UNIT TEST: Accept _____ Reject _____ Route to QA/ENG _____

Remarks:

* Record only upon special request from Engineering

	Signature	Date
Technician		
Engineering		
QA		
Govt. Insp.		

Right P-300120 Fuel Bypass Valve

DS-895380-1M
5-15-91

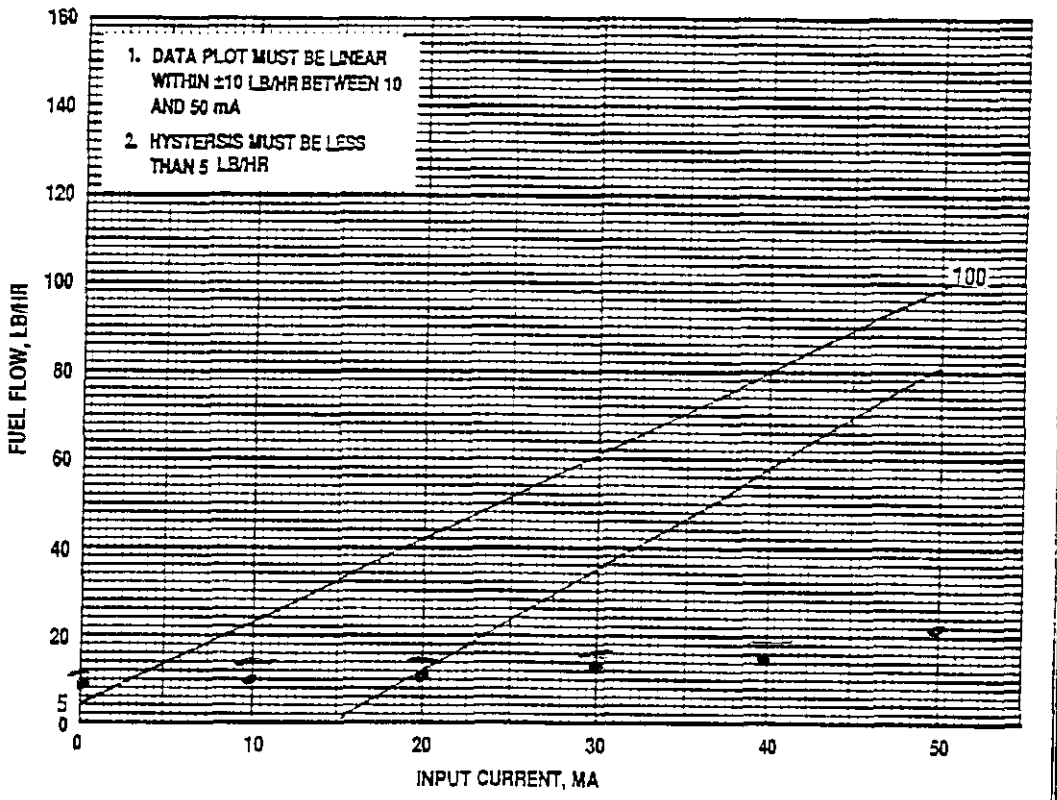
Valve Data Sheet

TI-895380 Rev: AA
Date: 7-10-2000

Valve Part Number: 895380-____ Serial Number: _____

3.1	Inspection (Check One): Accept ✓ Reject ___
3.2	Continuity Check:
(a)	Check for Short: Accept ✓ Reject ___
(b)	Resistance between pins "A" and "C" 203.9 (180 to 235 ohms required)
3.5	Torque Motor Current Cycle Check: ✓ (Check)
3.6	Internal Leakage Check: 1.33 lb/hr (5.0 lb/hr maximum allowable)
3.7	Linearity and Hysteresis Checks:

Current (±1 mA)	Actual Flow (lb/hr)
0	= 9.75
10	= 992
20	= 10.34
30	= 12.72
40	= 15.40
50	= 21.28
40	= 18.9
30	= 16.6
20	= 14.98
10	= 13.63
0	= 12.47



(f)	Minimum Flow = 22 (80.0 lb/hr minimum allowable) Noise (buzzing): Accept ✓ Reject ___
3.8	External Leakage Check: Accept ✓ Reject: ___

Acceptance Signatures
(As Required)

Test Laboratory _____

Accept ___ Reject ___

Quality Assurance _____

Remarks: _____

ATTACHMENT 1

WOODWARD GOVERNOR COMPANY ANALYTICAL REPORT #2194287-000328

(5 pages)

ENGINEERING ANALYTICAL REPORT

Class 1

WOODWARD GOVERNOR COMPANY
Aircraft Controls Group

CUSTOMER NAME	CAR NO	REPORT NO. (S/N - DATE)
National Transportation and Safety Board	N/A	2194287-000328

CUSTOMER ORDER		WOODWARD ORDER NO.	
1536014		2605625	
ENGINE TYPE	ENGINE SERIAL NUMBER	MODEL RECEIVED	ENGINE MFR. MODEL RECEIVED
TPE331	N/A	8070-311	893561-11
CONTROL TYPE		MODEL SHIPPED	ENGINE MFR. MODEL SHIPPED
2228		8070-311	893561-11
AIRCRAFT TYPE		AIRCRAFT TAIL NUMBER	
Mitsubishi MU-2B-26A		N 386 TM	

TSN	TSO	TSR
N/A	N/A	N/A

LAST SHIPPED	REPORT COMPLETION DATE
9/16/94	2000-4-17

REPORTED BY: Mike Moorman

SENIOR ENGINEER: Steve Krugler

1. PROBLEM DESCRIPTION

"Investigate per NTSB instruction – Unit was reported to have been involved in an incident in San Antonio, TX on Jan. 22, 2000."

2. CONCLUSIONS

Nothing was observed that would indicate the control was not operating properly prior to the incident. Flow anomalies observed are attributed to the Pt2 Bellows that had lost its evacuation. Elevated temperatures from a post-incident fire caused the solder to re-flow, opening the Bellows to end cap joint, allowing the pressure to increase within the bellows and shift flow schedules. The Pt2 Bellows simulator tool used for calibration was installed into the unit. Test data then confirmed proper function.
The disassembled control was returned to the customer.

3. CORRECTIVE ACTION

None required at this time.

4. INVESTIGATION DETAILS

Two units (see also report 1297874-000328) were returned to Woodward for investigation.

The following attended the investigation at Woodward, Rockton:

Jason Ragogna	NTSB, Air Safety Investigator
Jim Silliman	NTSB, Air Safety Investigator
Ralph Sorrells	Mitsubishi, Deputy General Manager
Norm Beauregard	Mitsubishi, Manager – Aircraft Technical Support
David Looper	Honeywell, Sr. Product Safety Specialist
Ed Leach	Woodward, Senior Engineer
Steve Krugler	Woodward, Senior Engineer
Mike Moorman	Woodward, Project Engineer

A visual examination of the unit was documented (see Fig. 1). The unit was subjected to an Audit Test on a production test stand. During initial drive rotation, unexpected noise was heard coming from the fuel control to pump interface. The fuel control was removed from the test stand. The drive pilot was removed. A small contaminate was found below the pilot. Under magnification, the contaminant was identified as a solder ball. It measured approximately .060 inch in diameter, and was not magnetic. The quill shaft was marred and slightly bent. The stub shaft that mates to the pump drive spline was removed from the pilot assembly, and testing continued without fuel control drive rotation.

The As Received condition (see Fig. 2) revealed anomalies very similar to those of report 1297874-000328, tested prior to this unit. Based on similar flow anomalies, the Pt2 Bellows was removed from the fuel control.

Class 1

ENGINEERING ANALYTICAL REPORT

A visual examination of the Pt2 Bellows showed a longer than normal length which is indicative of a loss of evacuation. The loss of evacuation is attributed to the re-flow of the solder as evidenced by a pool of solder on the inside of the Bellows base. This re-flow is attributed to the application of heat caused by the post-incident fire. Allstate 430 solder, which is used to attach and seal the bellows t the bellows end, has a re-melt temperature of 430 degrees F. It was agreed upon by all parties involved that the post-incident fire would reach temperatures well in excess of 430 degrees F. Similar re-flow of solder occurred at the Ballhead to gear joints. Once the solder cooled, the small solder balls were free to move within the fuel control during shipment to Woodward as well as during initial drive rotation on the Woodward test stand. A solder ball had become lodged at the drive gear to ballhead gear interface as evidenced by pressed solder into the root of one gear and markings at the tip of the mating gear tooth. It was this interference that caused the noise heard at initial drive rotation as well as the quill shaft damage.

The main cover mounting screws were loose as well. These screws required a ¾ to full turn to become finger tight. This looseness is also indicative of excess heat.

A second Audit run (see Figure 3) was completed using the Pt2 simulator tool with the specific gravity adjusted to as shipped conditions (.77). This data shows proper function. The simulator was used because damage to the case prevented installation of a new bellows assembly.

Class 1

ENGINEERING ANALYTICAL REPORT

Figure 1

Visual As Received Report — Aircraft Engine Systems

Type 2228
Small Gas Turbine Controls

DATE RECEIVED 00-3-28 — S/N N/A 2194287 (L.H)
ORDER NUMBER ______ — P/N N/A 8070-311
CUSTOMER ______ — CASE # 4155

Shipping Parts:
- ☐ O.K.– All Ports Covered
- ☐ Some Ports Covered (check box below if contaminated)
- ☐ No Ports Covered (check box below if contaminated)

Comments:
☑ Customer Parts in Shipping
S/O
Pump, Fittings, Linkage

Lockwire/Seals:

	WGC	Non-WGC	Missing
Cover Screws	☐	☑	☐
F/I Cover Plug	☐	☑	☐
Max Power Cover Plug	☐	☐	☑
Speed Setting Shaft	☐	☑	☐
Power Lever Shaft	☑	☐	☐
Power Lever Protractor	☐	☑	☐
Pt2 Bellows	☑	☐	☐
CDP Cover	☑	☐	☐
Other (comments)	☐	☐	☐

Comments:
→ Missing
Spec. Decal Not At 77

Apparent Damage:
- ☐ None
- ☐ Other Damage
- ☐ Speed Setting Shaft
- ☑ Cover Damage at 12 PT Screw Holes
- ☑ Case Damage near bellows (thin area)
- ☑ Case Damage near case marking
- ☑ Power Lever Shaft
- ☐ Check T2 Screw Holes
- ☐ Driveshaft

Comments:
☐ Photos taken
→ Bent, Screw Broke Off
→ Broken Off
P-2 Cap Missing

Other Comments:
- ☐ None
- ☐ Missing Screen and Plug
- ☐ Missing 12 PT Screw & Washer
- ☐ Missing P2 Cap Screw & Washer
- ☐ Need yellow cap (3009-013)
- ☐ Missing cap screw (188579) & nut (188041)
- ☐ Need cover decal (power shaft) (3081-192)
- ☐ Contaminated
- ☐ Rusty

Comments:

As Rec'd

FUEL CONTROL UNIT
ALLIEDSIGNAL INC.
AE PN 991935OCN ______ SERVICE BULLETINS
SN ______
MFR 66503 ______
WOODWARD
WOODWARD GOVERNOR COMPANY ROCKFORD, ILLINOIS

As Shipped

FUEL CONTROL UNIT
ALLIEDSIGNAL INC.
AE PN 991935OCN ______ SERVICE BULLETINS
SN ______
MFR 66503 ______
WOODWARD
WOODWARD GOVERNOR COMPANY ROCKFORD, ILLINOIS

Inspected By______________ Date:________

WOODWARD F27030/2000-03

WOODWARD GOVERNOR COMPANY
Rockford, Illinois
CAGE 66503

AS RECEIVED

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Audit Sheet

Control P/N 8070-311
Date 00.3.28
S/N 1294287
Case X-ray No. 4155

Test Stand No. 125 Sp. Gr. Setting = .77 or two clicks CW A-1
T2 Simulator No. 118820-25 Fuel Inlet Temp. = 75-80 deg. F
Fuel Pump P/N 6522 Fuel Inlet Press. = 15 ±2 psig

Test Point	Setting Sequencer Code: Test Point Description			Parameter Sequence Setting	A: Lever Positions USG Stop	B: Lever Positions MMV deg ±0.5	C: Speed RPM ±10 RPM	D: Tt2 deg F. ±2	E: Pt2 Hg A ±0.1 Hg	F: Ps3 psia ±0.2 psi	G: Ref Fuel Disch. Press. psig	Fuel Control Discharge Fuel Temp deg F. W.G Co.	Fuel Control Discharge Fuel Temp deg F. A/R	Fuel Flow pph Req'd	Fuel Flow pph W.G Co.	Fuel Flow pph A/R
1	USG Min. Stop 73%			ABDEFCG	Min.	0	3311 ±5	59	29.92	50	235			118 ±5		
2	USG Max. Stop 95.5%			ABDEFCG	Max.	0	4341 ±5	59	29.92	110	315			178 ±5		
3	OSG Set Point 104%			ABDEFCG	Max.	101	4717 ±5	59	29.92	160	375			220 ±10		
4	Accel-	S	Start Flow	See Para 1.0	Min.	0	1000	59	29.92	15	85	75		46 ±2	47	
5	eration	e	Breakpoint	Same as T.P. 4	Min.	0	1000	59	29.92	18.2 ±1	85	77		-	20.2	
6		aL	Std Day	ABCDEG	Min.	0	1000	59	29.92	19.5 ±1	210	82		70	20.8	
7		e	Std Day	ABCDEFG	Max.	0	2025	59	29.92	25	220	84		123 ±5	89	
8	Sched-	v	Hot Day	ABCDEFG	Max.	0	4000	103	29.92	130	525	89		458 ±21	453	
9	ule	e	Std Day	ABCDEFG	Max.	0	4000	59	29.92	130	500	89		438 ±20	453	
10		l	Altitude	ABCDEFG	Max.	0	4000	59	8.98	50	265			205 ±10		
11	Deceleration Schedule			ABCDEFG	Min.	0	4536	59	29.92	135	335			173 ±8		
12				ABCDEFG	Min.	0	4536	59	29.92	76	270			90 ±5		
13				ABCDEFG	Min.	0	4536	59	29.92	44	235			75 ±5		
14	Max. Wf Limit			ABCDEFG	Max.	0	4000	59	29.92	160	575	90		550 ±5	459	
15	Power	Flight Idle		ACFBEDG	Max.	40	4536	59	29.92	90	285			183 ±5		
16	Lever		Hot Day	ACFBEDG	Max.	101	4536	103	17.91	120	355			**		
17	Fuel		Std Day	ACFBEDG	Max.	101	4536	59	17.91	120	375			308 ±10		
18	Sched-		Cold Day	ACFBEDG	Max.	101	4536	-65	17.91	120	465			***		
19	ule		Altitude	ACFBEDG	Max.	101	4536	59	8.98	50	250			155 ±6		
20		Breakpoint		ACFBEDG	-	44	Set Conditions Same as Item15									

*Record Ps3
**Record Delta Wf from T.P. 17. Required = 38 ±15 pph
***Record Delta Wf from T.P. 17. Required = 115 ±15 pph

w/ bellows.

Figure 2

w/ bellows mike

WOODWARD GOVERNOR COMPANY
Rockford, Illinois
CAGE 66503

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Audit Sheet

AS RECEIVED

Control P/N 8070-311
Date 00-7-28
S/N 1294287
Case X-ray No. 4155

Test Stand No. 175 Sp. Gr. Setting = .77 or two clicks CW A-1
T2 Simulator No 1188220-25 Fuel Inlet Temp. = 75-80 deg. F
Fuel Pump P/N 6322 Fuel Inlet Press. = 15 ±2 psig

Test Point	Setting Sequencer Code: Test Point Description			Parameter Sequence Setting	A	B	C	D	E	F	G	Fuel Control Discharge Fuel Temp deg F.		Fuel Flow pph		
					Required Setting Parameters: Lever Positions		Speed RPM	Tt2 deg	Pt2 Hg A	Ps3 psia	Ref Fuel Disch.					
					USG Stop	MMV deg ±0.5	±10 RPM	F. ±2	±0.1 Hg	±0.2 psi	Press. psig	W.G Co.	A/R	Req'd	W.G Co.	A/R
1	USG Min. Stop 73%			ABDEFCG	Min.	0	3311 ±5	59	29.92	50	235			118 ±5		
2	USG Max. Stop 95.5%			ABDEFCG	Max.	0	4341 ±5	59	29.92	110	315			178 ±5		
3	OSG Set Point 104%			ABDEFCG	Max.	101	4717 ±5	59	29.92	160	375			220 ±10		
4	Accel-	S	Start Flow	See Para 1.0	Min.	0	1000	59	29.92	15	85	89	42	46 ±2	40	
5	eration	e	Breakpoint	Same as T.P. 4	Min.	0	1000	59	29.92	18.2 ±1	85	89		-	19.0	
6		aL	Std Day	ABCDEG	Min.	0	1000	59	29.92	19.5 ±1	210	89		70	21.5	
7		e	Std Day	ABCDEFG	Max.	0	2025	59	29.92	25	220	89	118	123 ±5	116	
8	Sched-	v	Hot Day	ABCDEFG	Max.	0	4000	103	29.92	130	525	92	444	458 ±21	440	
9		e	Std Day	ABCDEFG	Max.	0	4000	59	29.92	130	500	92	433	438 ±20	434	
10	ule	l	Altitude	ABCDEFG	Max.	0	4000	59	8.98	50	265	96		205 ±10	140	196
11	Deceleration Schedule			ABCDEFG	Min.	0	4536	59	29.92	135	335	102		173 ±8		
12				ABCDEFG	Min.	0	4536	59	29.92	76	270			90 ±5		
13				ABCDEFG	Min.	0	4536	59	29.92	44	235			75 ±5		
14	Max. Wf Limit			ABCDEFG	Max.	0	4000	59	29.92	160	575	92	456	550 ±5	454	
15	Power	Flight Idle		ACFBEDG	Max.	40	4536	59	29.92	90	285			183 ±5		
16	Lever		Hot Day	ACFBEDG	Max.	101	4536	103	17.91	120	355			**		
17	Fuel		Std Day	ACFBEDG	Max.	101	4536	59	17.91	120	375			308 ±10		
18	Sched-		Cold Day	ACFBEDG	Max.	101	4536	-65	17.91	120	465			***		
19	ule		Altitude	ACFBEDG	Max.	101	4536	59	8.98	50	250			155 ±6		
20		Breakpoint		ACFBEDG	-	44	Set Conditions Same as Item15									

*Record Ps3
**Record Delta Wf from T.P. 17. Required = 38 ±15 pph
***Record Delta Wf from T.P. 17. Required = 115 ±15 pph

11
SP. GR @ 77

Figure 3

ATTACHMENT 2

WOODWARD GOVERNOR COMPANY ANALYTICAL REPORT #1297874-000328

(8 pages)

ENGINEERING ANALYTICAL REPORT

Class 1

WOODWARD GOVERNOR COMPANY
Aircraft Controls Group

CUSTOMER NAME	CAR NO	REPORT NO. (S/N - DATE)
National Transportation and Safety Board	N/A	1297874-000328

CUSTOMER ORDER	WOODWARD ORDER NO.
1536013	2605624

ENGINE TYPE	ENGINE SERIAL NUMBER	MODEL RECEIVED	ENGINE MFR. MODEL RECEIVED
TPE331	N/A	8070-311	893561-11

CONTROL TYPE	MODEL SHIPPED	ENGINE MFR. MODEL SHIPPED
2228	8070-311	893561-11

AIRCRAFT TYPE	AIRCRAFT TAIL NUMBER
Mitsubishi MU-2B-26A	N 386 TM

TSN	TSO	TSR
N/A	N/A	N/A

LAST SHIPPED	REPORT COMPLETION DATE
9/16/94	2000-4-17

REPORTED BY: Mike Moorman

SENIOR ENGINEER: Steve Krugler

1. PROBLEM DESCRIPTION

"Investigate per NTSB instruction – Unit was reported to have been involved in an incident in San Antonio, TX, on Jan. 22, 2000"

2. CONCLUSIONS

Nothing was observed that would indicate the control was not operating properly prior to the incident. Flow anomalies observed are attributed to the Pt2 Bellows that had lost its evacuation. Elevated temperatures from a post-incident fire caused the solder to reflow, opening the Bellows to end cap joint, allowing the pressure to increase within the bellows and shift flow schedules. Replacement of the Pt2 Bellows confirmed proper function.

The disassembled control was returned to the customer.

3. CORRECTIVE ACTION

None required at this time.

4. INVESTIGATION DETAILS

Two units (see also report 2194287-000328) were returned to Woodward for investigation.

The following attended the investigation at Woodward, Rockton:

Jason Ragogna	NTSB, Air Safety Investigator
Jim Silliman	NTSB, Air Safety Investigator
Ralph Sorrells	Mitsubishi, Deputy General Manager
Norm Beauregard	Mitsubishi, Manager – Aircraft Technical Support
David Looper	Honeywell, Sr. Product Safety Specialist
Ed Leach	Woodward, Senior Engineer
Steve Krugler	Woodward, Senior Engineer
Mike Moorman	Woodward, Project Engineer

A visual examination of the unit was documented (see Fig. 1). The unit was subjected to an Audit Test on a production test stand. The As Received condition (see Fig. 2) revealed anomalies that required additional data points, thus the full detailed test schedules were run for Standard Day, Hot/Cold, and Altitude conditions (see Figures 3,4). A second Audit run was completed with the As Received conditions, adjusting only the specific gravity to the as shipped condition of .77 (see Figure 5). Based on the data acquired from Figure 5, the Pt2 Bellows, which senses ambient pressure, was replaced and a third Audit run was completed (see Figure 6) showing proper function.

Class 1

ENGINEERING ANALYTICAL REPORT

A visual examination of the Pt2 Bellows showed a longer than normal length which is indicative of a loss of evacuation. The loss of evacuation is attributed to the re-flow of the solder as evidenced by a pool of solder on the inside of the Bellows base. This re-flow is attributed to the application of heat caused by the post-incident fire. Allstate 430 solder, which is used to attach and seal the bellows to the bellows end piece, has a re-melt temperature of 430 degrees F. It was agreed upon by all parties involved that the post-crash fire would reach temperatures well in excess of 430 degrees F.

Class 1

ENGINEERING ANALYTICAL REPORT

Figure 1

Visual As Received Report — **Aircraft Engine Systems**

Type 2228
Small Gas Turbine Controls

DATE RECEIVED 00-3-28 S/N 1297874 (RH)
ORDER NUMBER _____ P/N 8070-311
CUSTOMER _____ CASE # N/A 4102

Shipping Parts:
- ☐ O.K.– All Ports Covered
- ☐ Some Ports Covered (check box below if contaminated)
- ☐ No Ports Covered (check box below if contaminated)

Comments:
- ☑ Customer Parts in Shipping
- S/O
- Pump, Fittings

Lockwire/Seals:	WGC	Non-WGC	Missing
Cover Screws	☐	☐	☑
F/I Cover Plug	☐	☐	☑
Max Power Cover Plug	☐	☐	☑
Speed Setting Shaft	☐	☐	☑
Power Lever Shaft	☑	☐	☐
Power Lever Protractor	☑	☐	☐
Pt2 Bellows	☑	☐	☐
CDP Cover	☑	☐	☐
Other (comments)	☐	☐	☐

Comments: Spec. Brow Not At 77 Increased As Far As Can Be

Apparent Damage:
- ☐ None
- ☐ Other Damage
- ☐ Speed Setting Shaft
- ☑ Power Lever Shaft → Bent
- ☐ Check T2 Screw Holes
- ☐ Driveshaft
- ☑ Cover Damage at 12 PT Screw Holes
- ☑ Case Damage near bellows (thin area)
- ☑ Case Damage near case marking

Comments:
- ☐ Photos taken.
- Lower Cracked By Bypass Area

Other Comments:
- ☐ None
- ☐ Missing Screen and Plug
- ☐ Missing 12 PT Screw & Washer
- ☐ Missing P2 Cap Screw & Washer
- ☐ Need yellow cap (3009-013)
- ☐ Missing cap screw (188579) & nut (188041)
- ☐ Need cover decal (power shaft) (3081-192)
- ☐ Contaminated
- ☐ Rusty

Comments:

As Rec'd

FUEL CONTROL UNIT
ALLIEDSIGNAL INC.
AE PN 99193SOCN _____ SERVICE BULLETINS
SN _____
MFR 66503 _____
WOODWARD
WOODWARD GOVERNOR COMPANY ROCKFORD, ILLINOIS

As Shipped

FUEL CONTROL UNIT
ALLIEDSIGNAL INC.
AE PN 99193SOCN _____ SERVICE BULLETINS
SN _____
MFR 66503 _____
WOODWARD
WOODWARD GOVERNOR COMPANY ROCKFORD, ILLINOIS

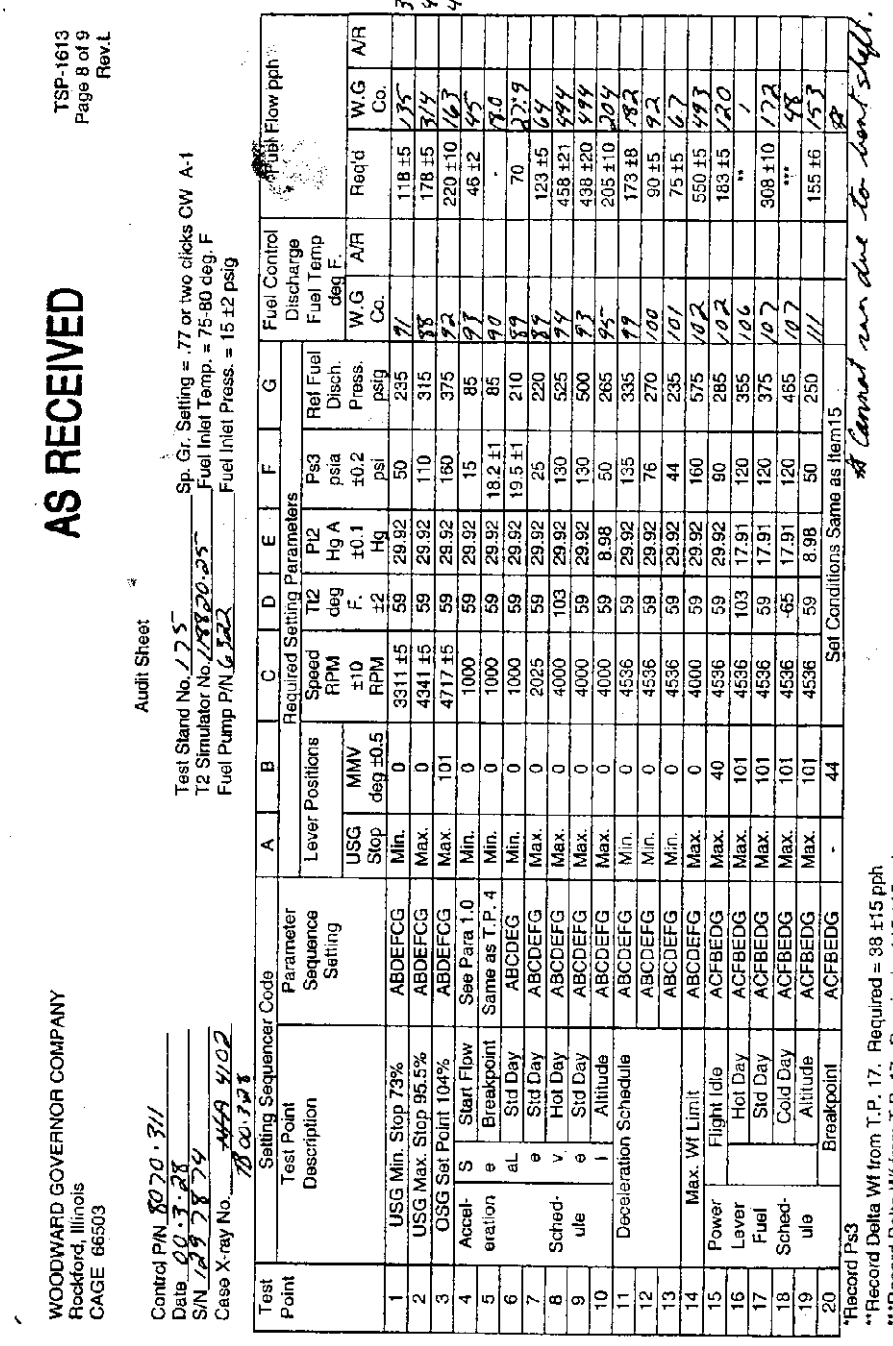
Inspected By_____Date:_____

WOODWARD F27030/2000-03

Class 1

ENGINEERING ANALYTICAL REPORT

Figure 2



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WOODWARD GOVERNOR COMPANY
Rockford, Illinois
CAGE 66503

Audit Sheet

Control P/N 8020-311
Date 09-13-18
S/N 1297874
Case X-ray No. 4459 4702
7800-328

Test Stand No. 225 — Sp. Gr. Setting = .77 or two clicks CW A-1
T2 Simulator No. 1288 20-25 — Fuel Inlet Temp. = 75-80 deg. F
Fuel Pump P/N 6322 — Fuel Inlet Press. = 15 ±2 psig

Test Point	Setting Sequencer Code: Test Point Description		Parameter Sequence Setting	A: Lever Positions USG Stop	A: Lever Positions MMV deg ±0.5	B: Required Setting Parameters Speed RPM ±10 RPM	T12 deg F. ±2	Pt2 Hg A ±0.1 Hg	Ps3 psia ±0.2 psi	G: Ref Fuel Disch. Press. psig	Fuel Control Discharge Fuel Temp deg F. W.G Co.	A/R	Fuel Flow pph Reqd	W.G Co.	A/R
1	USG Min. Stop 73%		ABDEFCG	Min.	0	3311 ±5	59	29.92	50	235	91		118 ±5	135	3962
2	USG Max. Stop 95.5%		ABDEFCG	Max.	0	4341 ±5	59	29.92	110	315	88		178 ±5	314	4971
3	OSG Set Point 104%		ABDEFCG	Max.	101	4717 ±5	59	29.92	160	375	92		220 ±10	163	4500
4	Accel-eration Schedule	S	Start Flow	Min.	0	1000	59	29.92	15	85	97		46 ±2	45	
5			See Para 1.0												
6		e	Breakpoint	Min.	0	1000	59	29.92	18.2 ±1	85	90		"	70	
7		aL	Same as T.P. 4												
8			Std Day ABCDEG	Min.	0	1000	59	29.92	19.5 ±1	210	89		70	32.9	
9	Sched-ule	e	Std Day ABCDEFG	Max.	0	2025	59	29.92	25	220	89		123 ±5	64	
10		v.	Hot Day ABCDEFG	Max.	0	4000	103	29.92	130	525	94		458 ±21	494	
11		e	Std Day ABCDEFG	Max.	0	4000	59	29.92	130	500	93		438 ±20	494	
12		l	Altitude ABCDEFG	Max.	0	4000	59	8.98	50	265	95		205 ±10	204	
13	Deceleration Schedule		ABCDEFG	Min.	0	4536	59	29.92	135	335	99		173 ±8	82	
14			ABCDEFG	Min.	0	4536	59	29.92	76	270	100		90 ±5	92	
15			ABCDEFG	Min.	0	4536	59	29.92	44	235	101		75 ±5	67	
16	Max. Wf Limit		ABCDEFG	Max.	0	4000	59	29.92	160	575	102		550 ±5	493	
17	Power Lever Fuel Sched-ule	Flight Idle	ACFBEDG	Max.	40	4536	59	29.92	90	285	102		183 ±5	120	
18		Hot Day	ACFBEDG	Max.	101	4536	103	17.91	120	355	106		"	/	
19		Std Day	ACFBEDG	Max.	101	4536	59	17.91	120	375	102		308 ±10	122	
20		Cold Day	ACFBEDG	Max.	101	4536	-65	17.91	120	465	102		"	98	
		Altitude	ACFBEDG	Max.	101	4536	59	8.98	50	250	111		155 ±6	153	
		Breakpoint	ACFBEDG	-	44	Set Conditions Same as Item15									

*Record Ps3
**Record Delta Wf from T.P. 17. Required = 38 ±15 pph
***Record Delta Wf from T.P. 17. Required = 115 ±15 pph

* Cannot run due to contrast.

Class 1

ENGINEERING ANALYTICAL REPORT

Figure 3

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Rockford, Illinois
CAGE 66503

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Hold Constant: Tt2 = 59 deg. F Pt2 = 14.7 psia											
Test Point	Inlet Flow pph Ref	Req'd Lever Positions deg.		Input Speed RPM +/-25	Ps3 psia	Pfn psig	Wf - pph		Wf- pph	Hysteresis	
		USG	MFL	Req'd	Req'd	Req'd	Req'd	Actual	Actual	Spec	Act.
1.1	150	Min.	0	450	15	50	Record	20	------	------	----
1.2	450	Min.	0	1000	15	85	46 ±2	41	------	------	----
1.3	450	Max.	0	1000	15	85	46 ±2	41	------	------	----
1.4**	450	Min.	0	1000	18.2 ±1	85	46 ±2	18.1	------	------	----
1.5***	450	Min.	0	1000	19.5 ±1	210	70	29.9	------	------	----
1.6	1000	Max.	0	2025	25	220	123 ±5	40	------	------	----
1.7	1400	Max.	0	3000	50	255	202 8±	136	------	------	----
1.8	1750	Max.	0	3600	70	295	266 ±10	279	------	------	----
1.9	1950	Max.	0	4000	90	335	309 12±	424		3	
1.10	1950	Max.	0	4000	120	420	388 ±15	423		6	
1.11	1950	Max.	0	4000	135	540	466 ±21	423	------	------	----
1.12	1950	Max.	0	4000	160	750	570 ±10	423	------	------	----

Remarks: **With Wf as specified increase Ps3 until Wf starts to increase. Record Ps3.
***Adjust Ps3 from a lower to a higher setting for exact Wf of 70 pph. Record Ps3.

Test Data Sheet
Altitude Acceleration Schedules

2 15,000 FOOT ACCEL SCHEDULE

Hold Constant: Tt2 = 59 deg. F Pt2 = 8.8 psia								
Test Point	Inlet Flow Ref	Required Lever Positions (deg.)		Input Speed	Ps3 psia	Pfn psig	Wf = pph	
		USG	MFL	Req'd	Req'd	Req'd	Req'd	Actual
2.1	450	Min.	0	1000	8.8	80	46 ±6	41
2.2	1400	Max.	0	3100	30	230	129 ±6	73
2.3	1950	Max.	0	4000	60	270	204 ±9	178
2.4	1950	Max.	0	4000	75	300	253 ±12	320
2.5	1950	Max.	Max.	4000	90	355	338 ±15	424

3 30,000 FOOT ACCEL SCHEDULE

Hold Constant: Tt2 = 59 deg. F Pt2 = 4.4 psia								
Test Point	Inlet Flow Ref	Required Lever Positions (deg.)		Input Speed	Ps3 psia	Pfn psig	Wf = pph	
		USG	MFL	Req'd	Req'd	Req'd	Req'd	Actual
3.1	1950	Max.	0	4000	25	225	99 ±4	80
3.2	1950	Max.	0	4000	35	240	122 ±5	109
3.3	1950	Max.	0	4000	50	265	205 ±10	196

Class 1

ENGINEERING ANALYTICAL REPORT

Figure 4

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Rockford, Illinois
CAGE 66503

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4 HOT DAY ACCEL SCHEDULE

Hold Constant: Tt2 = 103 deg. F Pt2 = 14.7 psia								
Test Point	Inlet Flow Ref	Required Lever Positions (deg.)		Input Speed	Ps3 psia	Pfn psig	Wf = pph	
		USG	MFL	Req'd	Req'd	Req'd	Req'd	Actual
4.1	450	Min.	0	1000	15	90	50 ±6	43
4.2	1600	Max.	0	3400	50	260	210 ±6	147
4.3	1950	Max.	0	4000	90	340	324 ±9	442
4.4	1950	Max.	0	4000	130	525	458 ±12	474

5 COLD DAY ACCEL SCHEDULE

Hold Constant: Tt2 = -60 deg. F Pt2 = 14.7 psia								
Test Point	Inlet Flow Ref	Required Lever Positions (deg.)		Input Speed	Ps3 psia	Pfn psig	Wf = pph	
		USG	MFL	Req'd	Req'd	Req'd	Req'd	Actual
5.1	450	Min.	0	1000	15	80	46 ±6	39
5.2	1400	Max.	0	3000	50	250	178 ±8	122
5.3	1850	Max.	0	3800	90	315	275 ±11	781
5.4	1950	Max.	0	4000	135	455	408 ±19	436
5.5	1950	Max.	101 deg.	4000	160	685	510 Min.	436

6 UNDERSPEED GOVERNOR 73% SPEED

Hold Constant: MFL = 0 deg. Tt2 = 59 deg. F Pt2 = 14.7 psia								
Test Point	USG Lever Positions		Input Speed ±5	Inlet Flow Ref	Ps3 psia	Pfn psig	Wf = pph	
	Req'd (deg.)	Actual	Req'd		Req'd	Req'd	Req'd	Actual
6.1	11.5 ±2.5	-	3210 Min.	1300	50	235	180 Min.	
6.2	11.5 ±2.5	-	3311	1300	50	235	118 ±5	
6.3	11.5 ±2.5	-	3333	1300	50	235	*	
6.4	11.5 ±2.5	-	3311	1300	50	235		

Remarks: *A Min. of 5 pph less than the fuel flow at Data Point 6.2

7 UNDERSPEED GOVERNOR 95.5% SPEED

Hold Constant: MFL = 0 deg. Tt2 = 59 deg. F Pt2 = 14.7 psia								
Test Point	USG Lever Positions		Input Speed ±5	Inlet Flow Ref	Ps3 psia	Pfn psig	Wf = pph	
	Req'd (deg.)	Actual	Req'd		Req'd	Req'd	Req'd	Actual
7.1	39 ±.25		4287 Min.	2050	135	360	252 Min.	
7.2	39 ±.25		4341	2150	110	315	178 ±5	
7.3	39 ±.25		4420	2150	110	315		
7.4	39 ±.25		4341	2150	110	315		
7.5	14 ±1		3400**	1500	55	250	122 ±3	

Remarks: ** Set speed and fuel flow. Record speed lever angle. Reg.: 14 +/- 1 deg.

WOODWARD GOVERNOR COMPANY
Rockford, Illinois
CAGE 66503

THIS RUN @ SG = 0.77 AS RECEIVED

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Audit Sheet

Control P/N 8070-311
Date 00-7-28
S/N 1297874
Case X-ray No. 4102

Test Stand No. 175 Sp. Gr. Setting = .77 or two clicks CW A-1
T2 Simulator No. 118820-25 Fuel Inlet Temp. = 75-80 deg. F
Fuel Pump P/N 6322 Fuel Inlet Press. = 15 ±2 psig

Test Point	Setting Sequencer Code / Test Point Description			Parameter Sequence Setting	A	B	C	D	E	F	G	Fuel Control Discharge Fuel Temp deg F.		Fuel Flow pph		
					Required Setting Parameters: Lever Positions		Speed RPM	Tt2 deg F.	Pt2 Hg A	Ps3 psia	Ref Fuel Disch. Press. psig					
					USG Stop	MMV deg ±0.5	±10 RPM	±2	±0.1 Hg	±0.2 psi		W.G Co.	A/R	Req'd	W.G Co.	A/R
1	USG Min. Stop 73%			ABDEFCG	Min.	0	3311 ±5	59	29.92	50	235	109		118 ±5	136	
2	USG Max. Stop 95.5%			ABDEFCG	Max.	0	4341 ±5	59	29.92	110	315	104		178 ±5	303	
3	OSG Set Point 104%			ABDEFCG	Max.	101	4717 ±5	59	29.92	160	375	105		220 ±10	143	
4	Accel-eration Sched-ule	S	Start Flow	See Para 1.0	Min.	0	1000	59	29.92	15	85	104		46 ±2	41	
5		e	Breakpoint	Same as T.P. 4	Min.	0	1000	59	29.92	18.2 ±1	85	103		-	18.4	
6		aL	Std Day	ABCDEG	Min.	0	1000	59	29.92	19.5 ±1	210	102		70	28.4	
7		e	Std Day	ABCDEFG	Max.	0	2025	59	29.92	25	220	101		123 ±5	61	
8		v	Hot Day	ABCDEFG	Max.	0	4000	103	29.92	130	525	102		458 ±21	474	
9		e	Std Day	ABCDEFG	Max.	0	4000	59	29.92	130	500	100		438 ±20	474	
10		l	Altitude	ABCDEFG	Max.	0	4000	59	8.98	50	265	103		205 ±10	197	
11	Deceleration Schedule			ABCDEFG	Min.	0	4536	59	29.92	135	335	107		173 ±8	174	
12				ABCDEFG	Min.	0	4536	59	29.92	76	270	108		90 ±5	88	
13				ABCDEFG	Min.	0	4536	59	29.92	44	235	108		75 ±5	64	
14	Max. Wf Limit			ABCDEFG	Max.	0	4000	59	29.92	160	575	110		550 ±5	472	
15	Power Lever Fuel Sched-ule	Flight Idle		ACFBEDG	Max.	40	4536	59	29.92	90	285	109		183 ±5	114	
16			Hot Day	ACFBEDG	Max.	101	4536	103	17.91	120	355	113		**	0	
17			Std Day	ACFBEDG	Max.	101	4536	59	17.91	120	375	113		308 ±10	165	
18			Cold Day	ACFBEDG	Max.	101	4536	-65	17.91	120	465	114		***	42	
19			Altitude	ACFBEDG	Max.	101	4536	59	8.98	50	250	116		155 ±6	145	
20		Breakpoint		ACFBEDG	-	44	Set Conditions Same as Item15								#	

*Record Ps3
**Record Delta Wf from T.P. 17. Required = 38 ±15 pph
***Record Delta Wf from T.P. 17. Required = 115 ±15 pph

SP. GR ↓ 5 click increase
Could not run.

Figure 5

WOODWARD GOVERNOR COMPANY
Rockford, Illinois
CAGE 66503

DATA TAKEN WITH BELLOWS (P_2) FROM ANOTHER UNIT

TSP-1613
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Rev.L

Audit Sheet SG @ .77

AS RECEIVED

Control P/N 8270-311
Date 00.3.28
S/N 1297874
Case X-ray No. 4102

Test Stand No. 175 Sp. Gr. Setting = .77 or two clicks CW A-1
T2 Simulator No. 118820-25 Fuel Inlet Temp. = 75-80 deg. F
Fuel Pump P/N 6522 Fuel Inlet Press. = 15 ±2 psig

Test Point	Setting Sequencer Code / Test Point Description			Parameter Sequence Setting	A	B	C	D	E	F	G	Fuel Control Discharge Fuel Temp deg F.		Fuel Flow pph		
					Required Setting Parameters: Lever Positions		Speed RPM	Tt2, deg F.	Pt2 Hg A	Ps3 psia	Ref Fuel Disch. Press. psig					
					USG Stop	MMV deg ±0.5	±10 RPM	±2	±0.1 Hg	±0.2 psi		W.G Co.	A/R	Req'd	W.G Co.	A/R
1	USG Min. Stop 73%			ABDEFCG	Min.	0	3311 ±5	59	29.92	50	235	94		118 ±5	192	
2	USG Max. Stop 95.5%			ABDEFCG	Max.	0	4341 ±5	59	29.92	110	315	94		178 ±5	293	
3	OSG Set Point 104%			ABDEFCG	Max.	101	4717 ±5	59	29.92	160	375	93		220 ±10	184	
4	Accel-eration Sched-ule	S e aL e v e l	Start Flow	See Para 1.0	Min.	0	1000	59	29.92	15	85	94		46 ±2	40	
5			Breakpoint	Same as T.P. 4	Min.	0	1000	59	29.92	18.2 ±1	85	92		-	18.5	
6			Std Day	ABCDEG	Min.	0	1000	59	29.92	19.5 ±1	210	92		70	29.2	
7			Std Day	ABCDEFG	Max.	0	2025	59	29.92	25	220	91		123 ±5	115	
8			Hot Day	ABCDEFG	Max.	0	4000	103	29.92	130	525	91		458 ±21	457	
9			Std Day	ABCDEFG	Max.	0	4000	59	29.92	130	500	89		438 ±20	441	
10			Altitude	ABCDEFG	Max.	0	4000	59	8.98	50	265	98		205 ±10	203	
11	Deceleration Schedule			ABCDEFG	Min.	0	4536	59	29.92	135	335	101		173 ±8	169	
12				ABCDEFG	Min.	0	4536	59	29.92	76	270	102		90 ±5	81	
13				ABCDEFG	Min.	0	4536	59	29.92	44	235	103		75 ±5	64	
14	Max. Wf Limit			ABCDEFG	Max.	0	4000	59	29.92	160	575	89	473	~~550~~ ±5	479	
15	Power Lever Fuel Sched-ule	Flight Idle		ACFBEDG	Max.	40	4536	59	29.92	90	285	108		183 ±5	186	
16			Hot Day	ACFBEDG	Max.	101	4536	103	17.91	120	355	106		**	38	
17			Std Day	ACFBEDG	Max.	101	4536	59	17.91	120	375	105		308 ±10	301	
18			Cold Day	ACFBEDG	Max.	101	4536	-65	17.91	120	465	103		***	115	
19			Altitude	ACFBEDG	Max.	101	4536	59	8.98	50	250	106		155 ±6	147	
20		Breakpoint		ACFBEDG	-	44	Set Conditions Same as Item15									

3476
4418
4206

*Record Ps3
**Record Delta Wf from T.P. 17. Required = 38 ±15 pph
***Record Delta Wf from T.P. 17. Required = 115 ±15 pph

EC 102 999-97 DATED 23 AUG. 96
CHANGED MAX FLOW FROM
473 ±5 PPH TO 550 ±5 PPH.
THIS UNIT LAST SHIPPED 9/94.

Figure 6